ACM CIKM 2022

International Workshop on Privacy Algorithms in Systems

Privacy in the Age of AI and the Internet of Things

Norman Sadeh
Professor of Computer Science
Co-Director, Privacy Engineering Program
Carnegie Mellon University

https://normsadeh.org

Privacy Threats Are Everywhere

Source: CSO online

Data-Hungry Economy

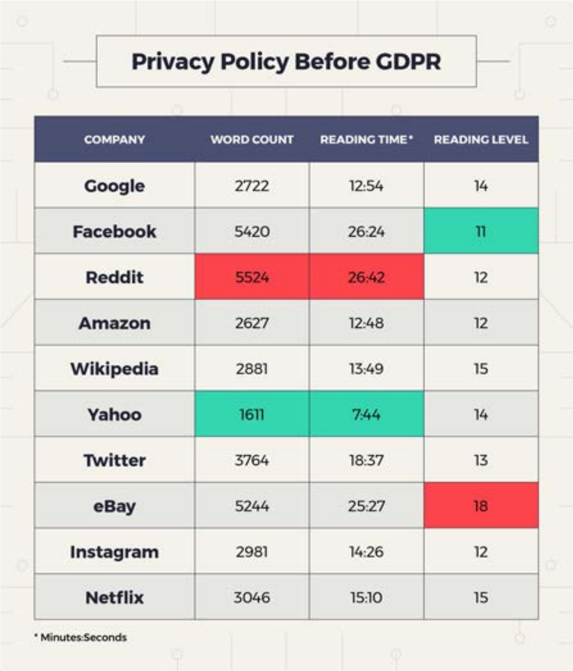
- AI/ML
- IoT sensors everywhere
- Myriads of APIs and dataflows

  and also:
- unscrupulous/ignorant data collectors/processors

New Regulations

- Increasingly more specific data practice disclosure requirements
- Increasingly specific data subject rights
- Emerging, yet loosely specified, usability expectations
- AI & Privacy – Broadening Expectations (e.g., Interpretability)
- New, significantly steeper financial penalties

“All is for the Best in the Best of Possible Worlds” (Voltaire)

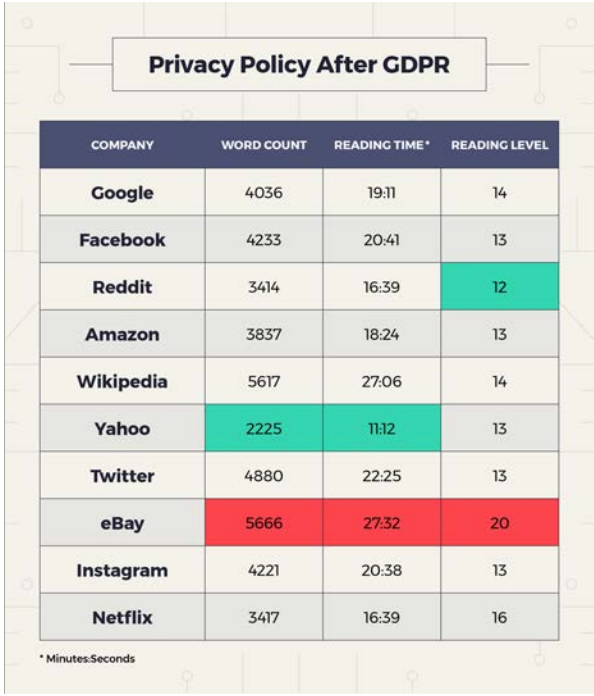


Privacy Policy Before GDPR

COMPANY	WORD COUNT	READING TIME*	READING LEVEL
Google	2722	12:54	14
Facebook	5420	26:24	11
Reddit	5524	26:42	12
Amazon	2627	12:48	12
Wikipedia	2881	13:49	15
Yahoo	1611	7:44	14
Twitter	3764	18:37	13
eBay	5244	25:27	18
Instagram	2981	14:26	12
Netflix	3046	15:10	15

* Minutes:Seconds

Progress?



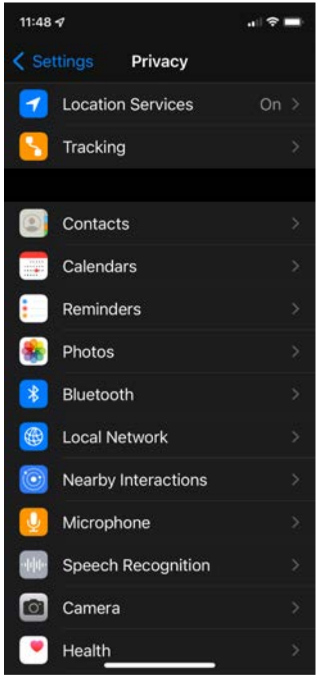
Privacy Policy After GDPR

COMPANY	WORD COUNT	READING TIME*	READING LEVEL
Google	4036	19:11	14
Facebook	4233	20:41	13
Reddit	3414	16:39	12
Amazon	3837	18:24	13
Wikipedia	5617	27:06	14
Yahoo	2225	11:12	13
Twitter	4880	22:25	13
eBay	5666	27:32	20
Instagram	4221	20:38	13
Netflix	3417	16:39	16

* Minutes:Seconds

Source: https://www.varonis.com/blog/gdpr-privacy-policy

…And Who Has the Time to Review & Manage All these Privacy Settings?



11:48

Settings Privacy

Location Services On

Tracking

Contacts

Calendars

Reminders

Photos

Bluetooth

Local Network

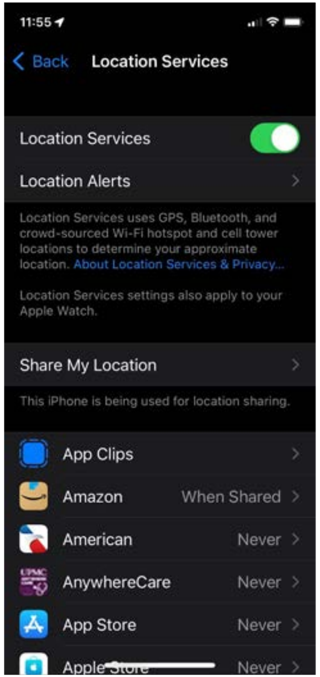
Nearby Interactions

Microphone

Speech Recognition

Camera

Health



11:55

Back Location Services

Location Services

Location Alerts

Location Services uses GPS, Bluetooth, and crowd-sourced Wi-Fi hotspot and cell tower locations to determine your approximate location. About Location Services & Privacy…

Location Services settings also apply to your Apple Watch.

Share My Location

This iPhone is being used for location sharing.

App Clips

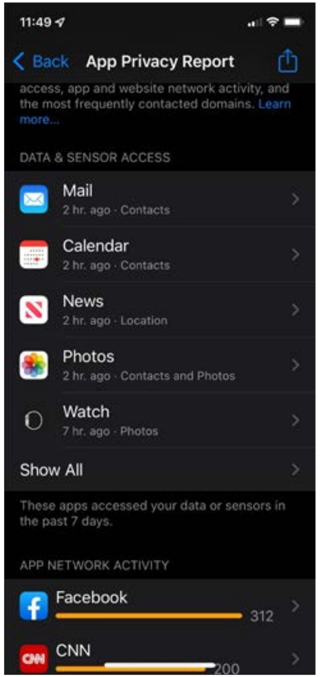
Amazon When Shared

American Never

AnywhereCare Never

App Store Never

Apple Store Never



11:49

Back App Privacy Report

access, app and website network activity, and the most frequently contacted domains. Learn more…

DATA & SENSOR ACCESS

Mail
2 hr. ago · Contacts

Calendar
2 hr. ago · Contacts

News
2 hr. ago · Location

Photos
2 hr. ago · Contacts and Photos

Watch
7 hr. ago · Photos

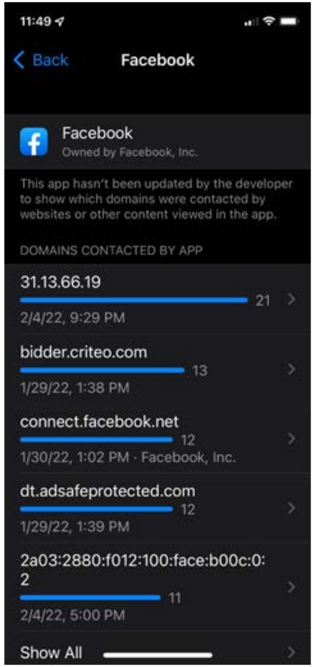
Show All

These apps accessed your data or sensors in the past 7 days.

APP NETWORK ACTIVITY

Facebook 312

CNN 200



11:49

Back Facebook

Facebook
Owned by Facebook, Inc.

This app hasn't been updated by the developer to show which domains were contacted by websites or other content viewed in the app.

DOMAINS CONTACTED BY APP

31.13.66.19 21
2/4/22, 9:29 PM

bidder.criteo.com 13
1/29/22, 1:38 PM

connect.facebook.net 12
1/30/22, 1:02 PM · Facebook, Inc.

dt.adsafeprotected.com 12
1/29/22, 1:39 PM

2a03:2880:f012:100:face:b00c:0:2 11
2/4/22, 5:00 PM

Show All

The Human Bottleneck

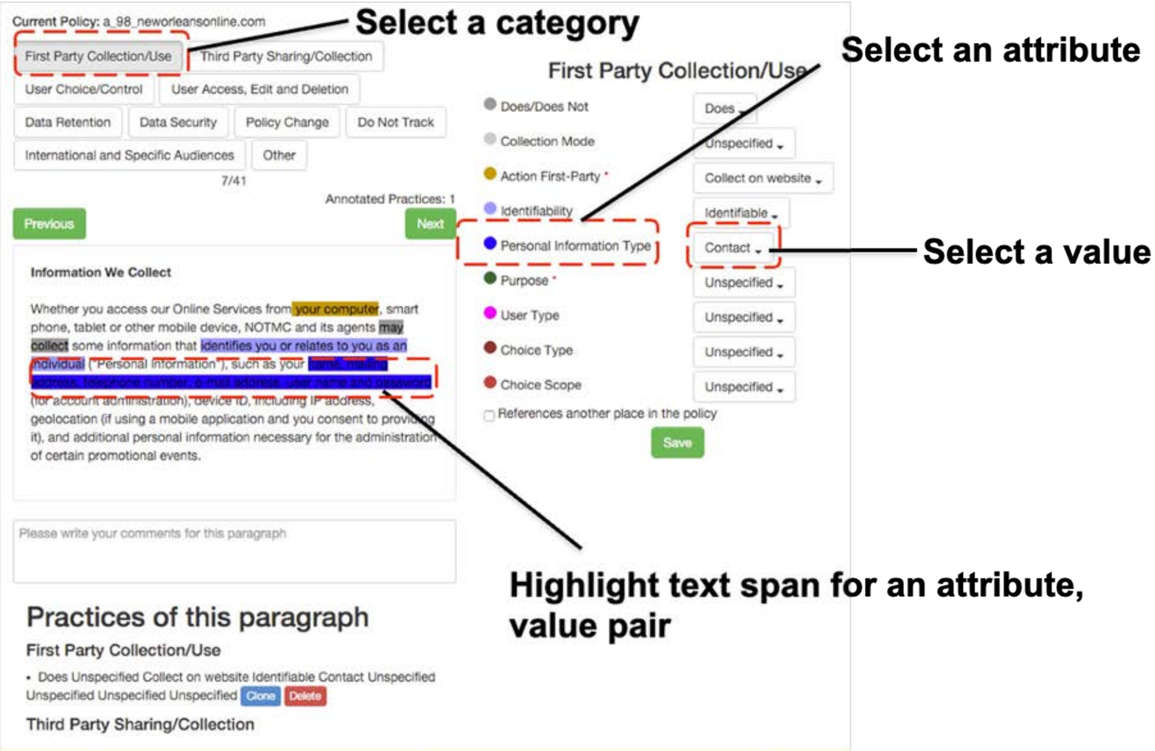
Lack of:

- **Expertise**
- **Time**
- **Attention**
- **Motivation**
- **etc.**

Source: https://www.datanami.com/2016/09/13/sas-goes-back-future-cognitive-computing-viya/

What If Computers Understood the Text of Privacy Policies?

Annotation Tool



Current Policy: a_98_neworleansonline.com

First Party Collection/Use | Third Party Sharing/Collection | User Choice/Control | User Access, Edit and Deletion | Data Retention | Data Security | Policy Change | Do Not Track | International and Specific Audiences | Other

7/41

Annotated Practices: 1

Previous | Next

Information We Collect

Whether you access our Online Services from your computer, smart phone, tablet or other mobile device, NOTMC and its agents may collect some information that identifies you or relates to you as an individual ("Personal Information"), such as your name, mailing address, telephone number, e-mail address, user name and password (for account administration), device ID, including IP address, geolocation (if using a mobile application and you consent to providing it), and additional personal information necessary for the administration of certain promotional events.

Please write your comments for this paragraph

Practices of this paragraph

First Party Collection/Use

- Does Unspecified Collect on website Identifiable Contact Unspecified Unspecified Unspecified Unspecified Clone Delete

Third Party Sharing/Collection

First Party Collection/Use

● Does/Does Not	Does
● Collection Mode	Unspecified
● Action First-Party *	Collect on website
● Identifiability	Identifiable
● Personal Information Type	Contact
● Purpose *	Unspecified
● User Type	Unspecified
● Choice Type	Unspecified
● Choice Scope	Unspecified

□ References another place in the policy

Save

Select a category

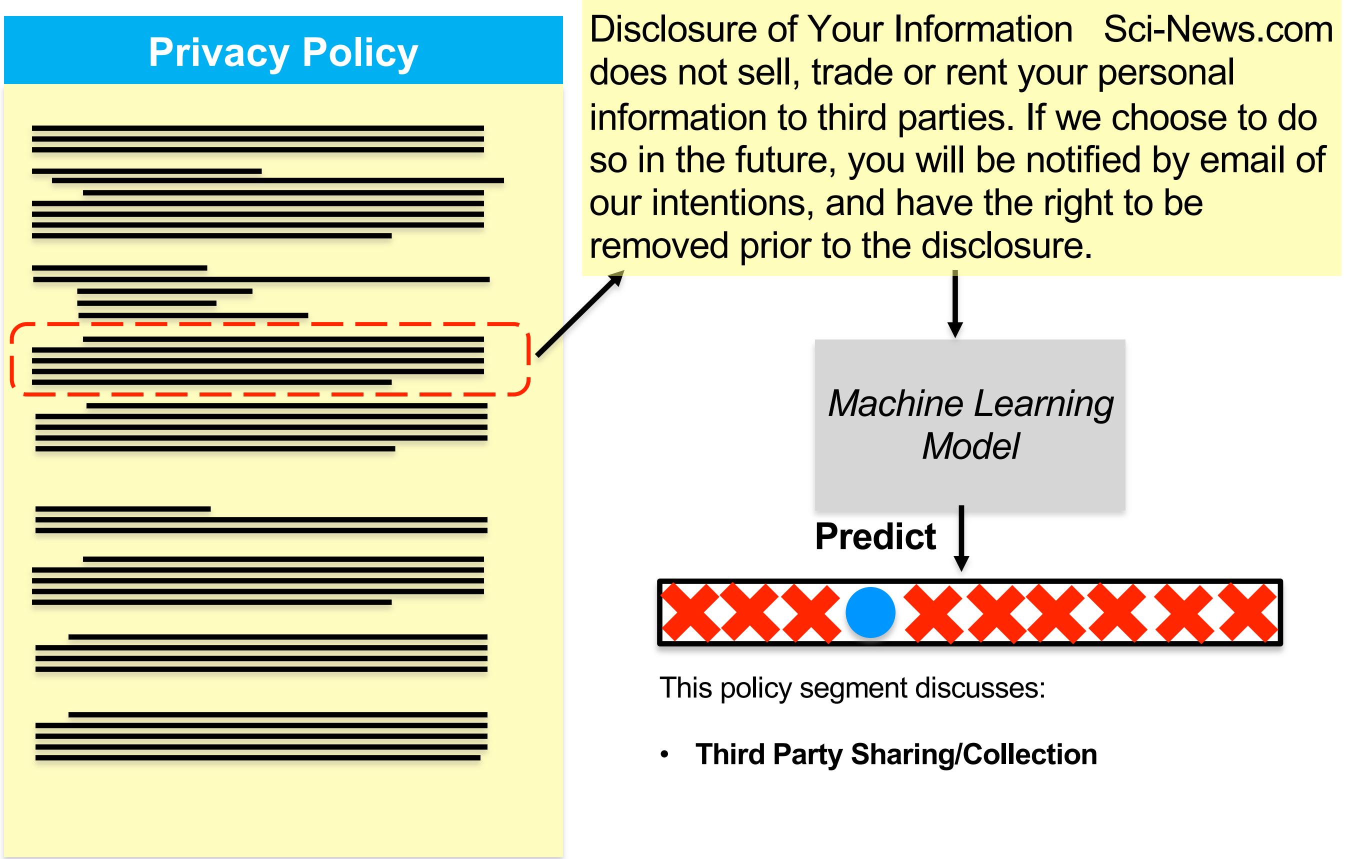
Select an attribute

Select a value

Highlight text span for an attribute, value pair

S. Wilson, F. Schaub, A. Dara, F. Liu, S. Cherivirala, P.G. Leon, M.S. Andersen, S. Zimmeck, K. Sathyendra, N.C. Russell, T.B. Norton, E. Hovy, J.R. Reidenberg, N. Sadeh, "The Creation and Analysis of a Website Privacy Policy Corpus", ACL '16: Annual Meeting of the Association for Computational Linguistics, Aug 2016

A First Task: Segment Annotation

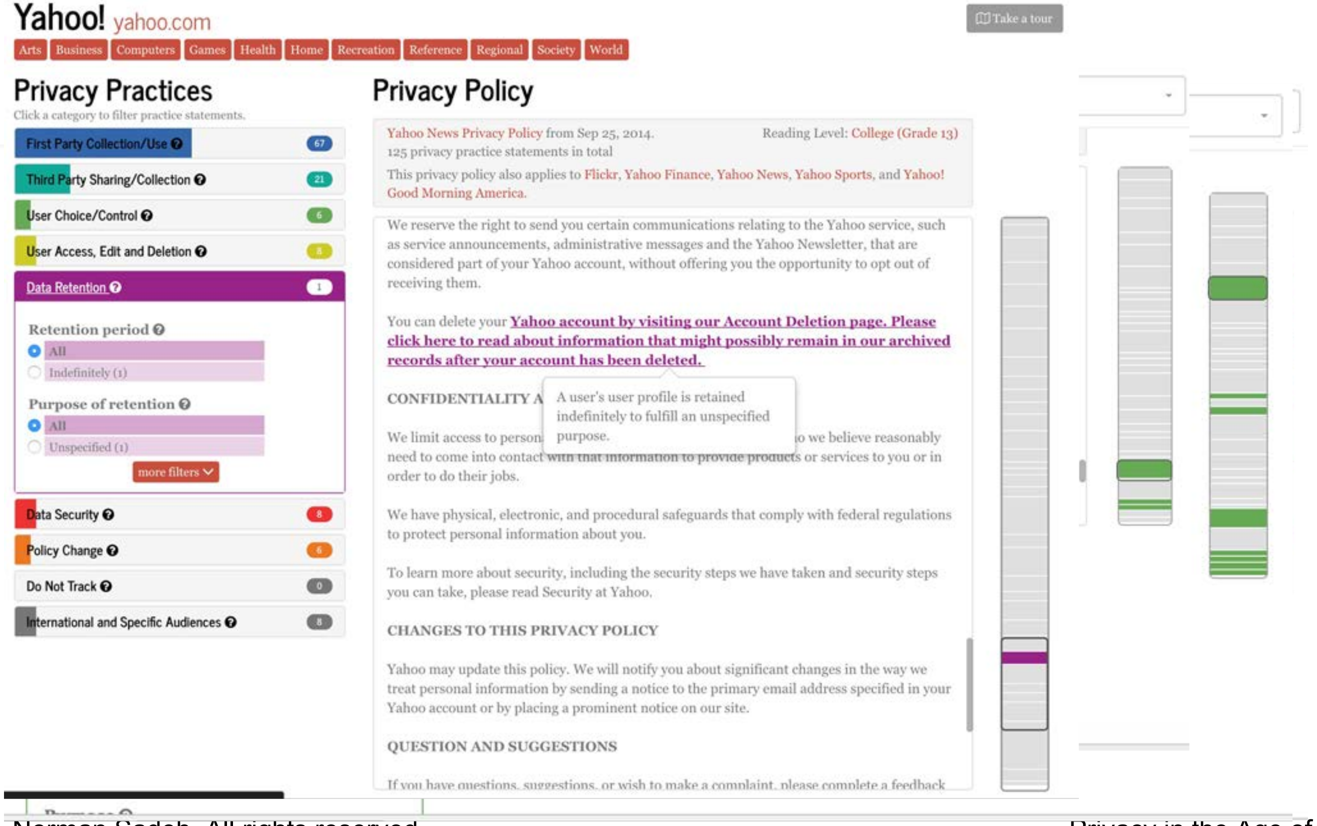


Disclosure of Your Information Sci-News.com does not sell, trade or rent your personal information to third parties. If we choose to do so in the future, you will be notified by email of our intentions, and have the right to be removed prior to the disclosure.

This policy segment discusses:

- **Third Party Sharing/Collection**

Automatic Identification of Data Practice Disclosures



Yahoo! yahoo.com

Privacy Practices

Click a category to filter practice statements.

First Party Collection/Use	67
Third Party Sharing/Collection	21
User Choice/Control	6
User Access, Edit and Deletion	8
Data Retention	1

Retention period
- ● All
- ○ Indefinitely (1)

Purpose of retention
- ● All
- ○ Unspecified (1)

Data Security	8
Policy Change	6
Do Not Track	0
International and Specific Audiences	8

Privacy Policy

Yahoo News Privacy Policy from Sep 25, 2014. Reading Level: College (Grade 13)

125 privacy practice statements in total

This privacy policy also applies to Flickr, Yahoo Finance, Yahoo News, Yahoo Sports, and Yahoo! Good Morning America.

We reserve the right to send you certain communications relating to the Yahoo service, such as service announcements, administrative messages and the Yahoo Newsletter, that are considered part of your Yahoo account, without offering you the opportunity to opt out of receiving them.

You can delete your **Yahoo account by visiting our Account Deletion page. Please click here to read about information that might possibly remain in our archived records after your account has been deleted.**

A user's user profile is retained indefinitely to fulfill an unspecified purpose.

CONFIDENTIALITY A

We limit access to person o we believe reasonably need to come into contact with that information to provide products or services to you or in order to do their jobs.

We have physical, electronic, and procedural safeguards that comply with federal regulations to protect personal information about you.

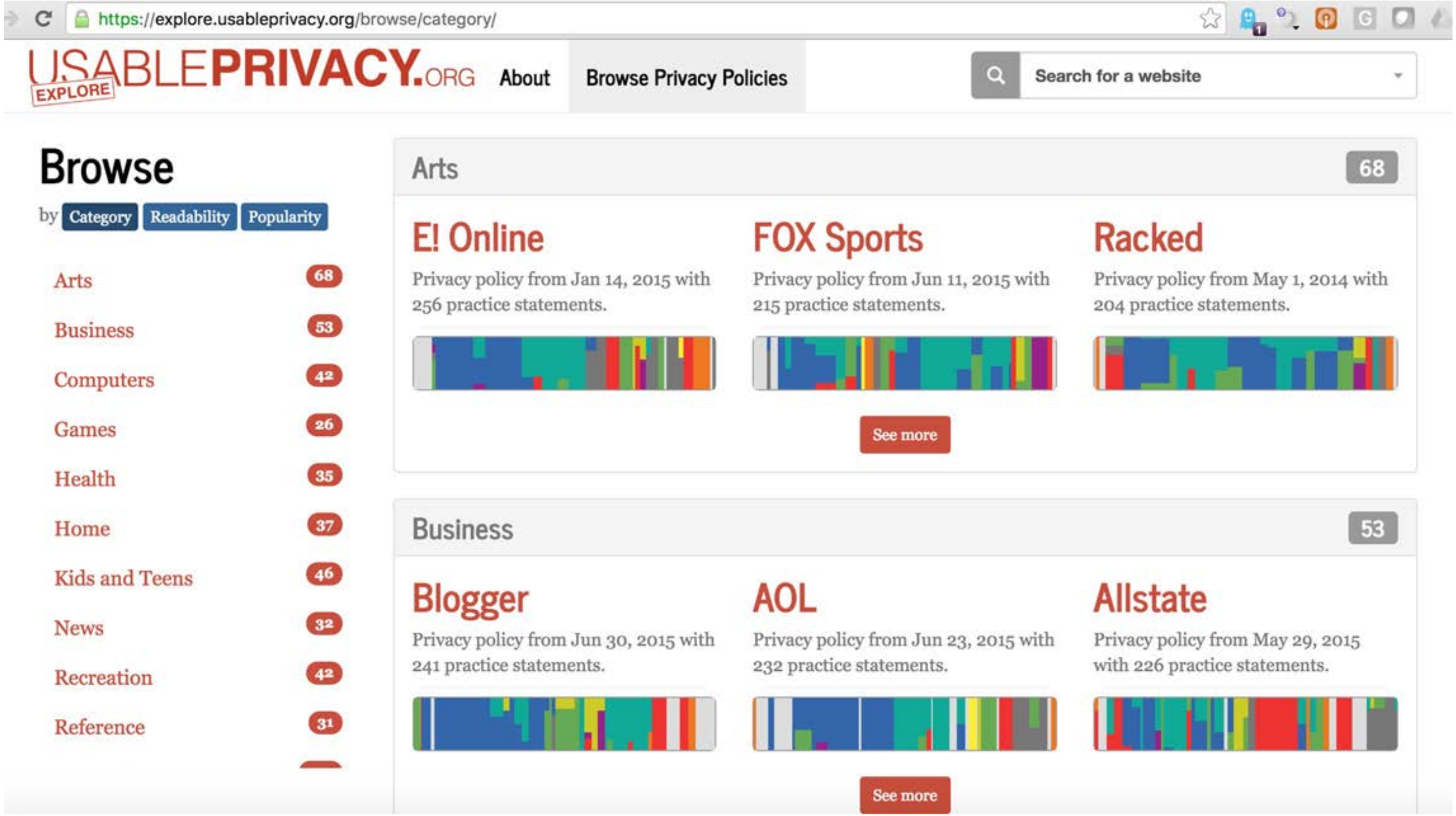
To learn more about security, including the security steps we have taken and security steps you can take, please read Security at Yahoo.

CHANGES TO THIS PRIVACY POLICY

Yahoo may update this policy. We will notify you about significant changes in the way we treat personal information by sending a notice to the primary email address specified in your Yahoo account or by placing a prominent notice on our site.

QUESTION AND SUGGESTIONS

If you have questions, suggestions, or wish to make a complaint, please complete a feedback



https://explore.usableprivacy.org/browse/category/

Browse

by Category Readability Popularity

Arts	68
Business	53
Computers	42
Games	26
Health	35
Home	37
Kids and Teens	46
News	32
Recreation	42
Reference	31

Arts 68

E! Online
Privacy policy from Jan 14, 2015 with 256 practice statements.

FOX Sports
Privacy policy from Jun 11, 2015 with 215 practice statements.

Racked
Privacy policy from May 1, 2014 with 204 practice statements.

See more

Business 53

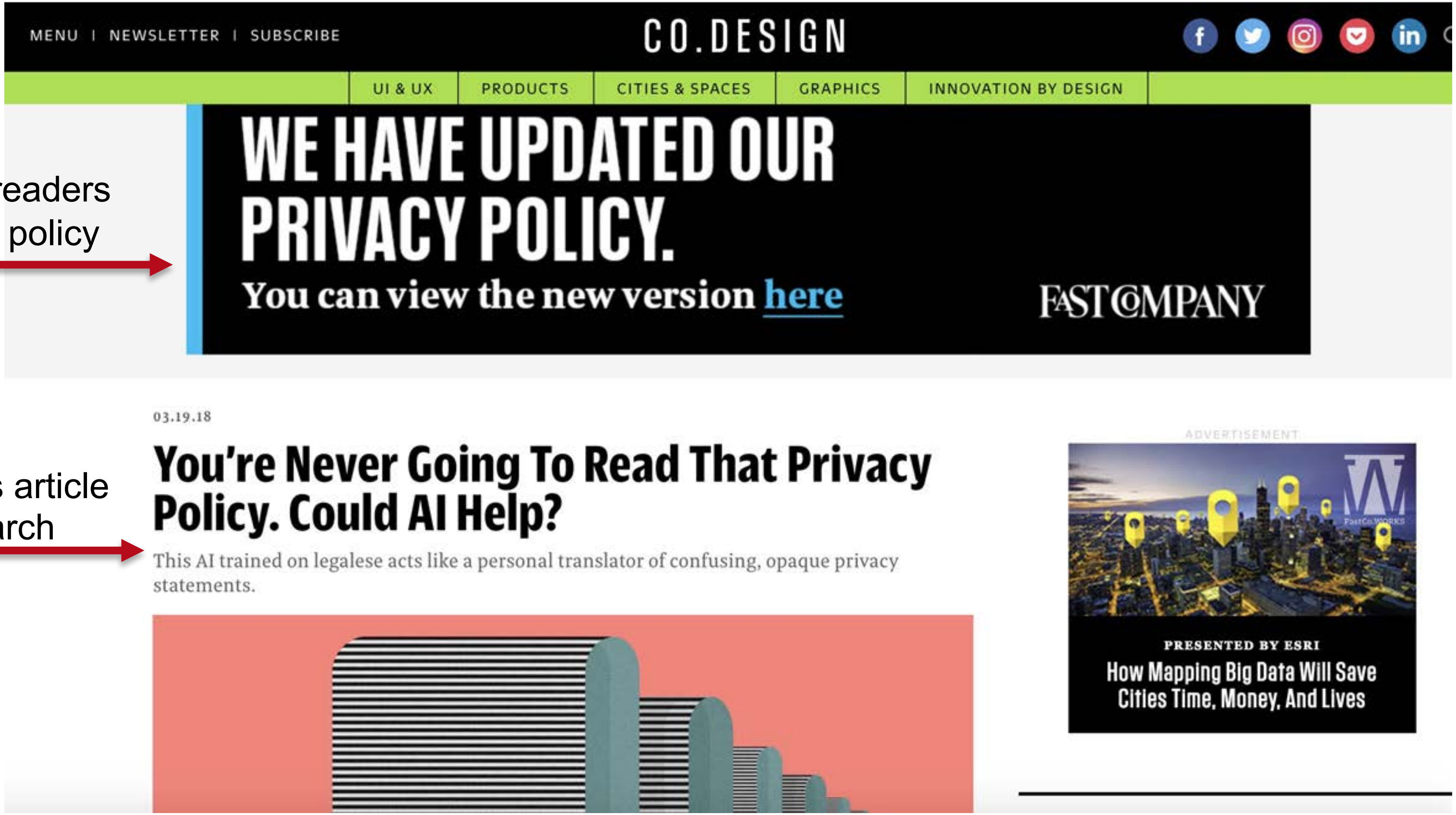
Blogger
Privacy policy from Jun 30, 2015 with 241 practice statements.

AOL
Privacy policy from Jun 23, 2015 with 232 practice statements.

Allstate
Privacy policy from May 29, 2015 with 226 practice statements.

See more

Press Coverage – Notice the Irony



FastCompany informing their readers about their new policy

WE HAVE UPDATED OUR PRIVACY POLICY.

You can view the new version here

FASTCOMPANY

FastCompany's article about our research

03.19.18

You're Never Going To Read That Privacy Policy. Could AI Help?

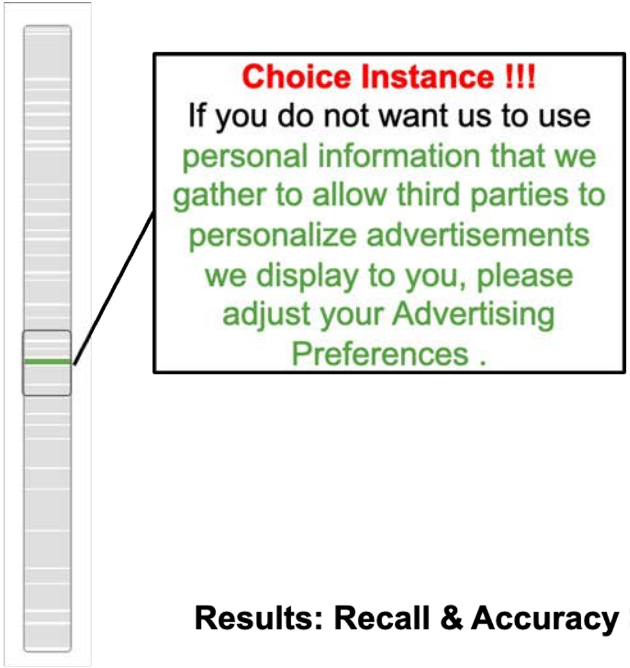
This AI trained on legalese acts like a personal translator of confusing, opaque privacy statements.

Privacy Question Answering

- **One-size-fits-all summaries of privacy policies only go so far**
- Different people have different questions at different points in time
- Could we develop privacy question answering functionality?
- A number of challenges
  - Can people accurately articulate their questions. If not, how can we help them?
  - How do we provide useful answers – vague policies, inaccurate classifiers
  - etc.

Question answering for privacy policies: Combining computational and legal perspectives. A Ravichander, AW Black, S Wilson, T Norton, N Sadeh, EMNL 2019 Conference, arXiv preprint arXiv:1911.00841
Breaking Down Walls of Text: How Can NLP Benefit Consumer Privacy?, A Ravichander, AW Black, T Norton, S Wilson, N Sadeh, ACL/IJCNLP 2021. http://dx.doi.org/10.18653/v1/2021.acl-long.319

User Choice Instance Extraction



Choice Instance !!!
If you do not want us to use personal information that we gather to allow third parties to personalize advertisements we display to you, please adjust your Advertising Preferences .

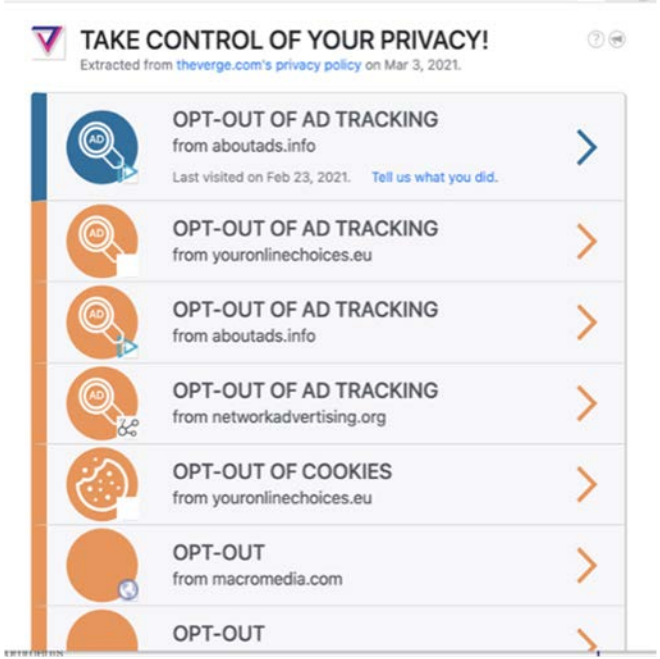
- User choices often buried deep in the text of long policies
- Is it possible to **automatically extract information** about such "choice instances" from privacy policies?
- Use Natural Language Toolkit tokenizer to subdivide segments into sentences & build classifiers

Results: Recall & Accuracy > 90%

Vinayshekhar Bannihatti Kumar, Roger Iyengar, Namita Nisal, Yuanyuan Feng, Hana Habib, Peter Story, Sushain Cherivirala, Margaret Hagan, Lorrie Faith Cranor, Shomir Wilson, Florian Schaub, Norman Sadeh, **"Finding a Choice in a Haystack: Automatic Extraction of Opt-Out Statements from Privacy Policy Text"**, WWW '20, Apr 2020 [pdf]

Opt-Out Easy Browser Extension

- Automatically identify and categorize opt-out choices in the text of privacy policies
- And present them in an easy-to-use interface to users as they browse the web
- Available in Google Chrome store and Firefox store - Watch our video



TAKE CONTROL OF YOUR PRIVACY!

Extracted from theverge.com's privacy policy on Mar 3, 2021.

OPT-OUT OF AD TRACKING
from aboutads.info
Last visited on Feb 23, 2021. Tell us what you did.

OPT-OUT OF AD TRACKING
from youronlinechoices.eu

OPT-OUT OF AD TRACKING
from aboutads.info

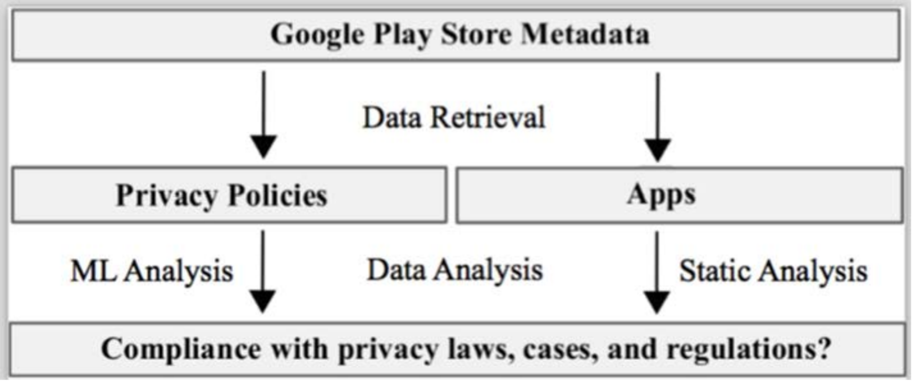
OPT-OUT OF AD TRACKING
from networkadvertising.org

OPT-OUT OF COOKIES
from youronlinechoices.eu

OPT-OUT
from macromedia.com

OPT-OUT

Can We Automatically Check for Potential Compliance Issues?

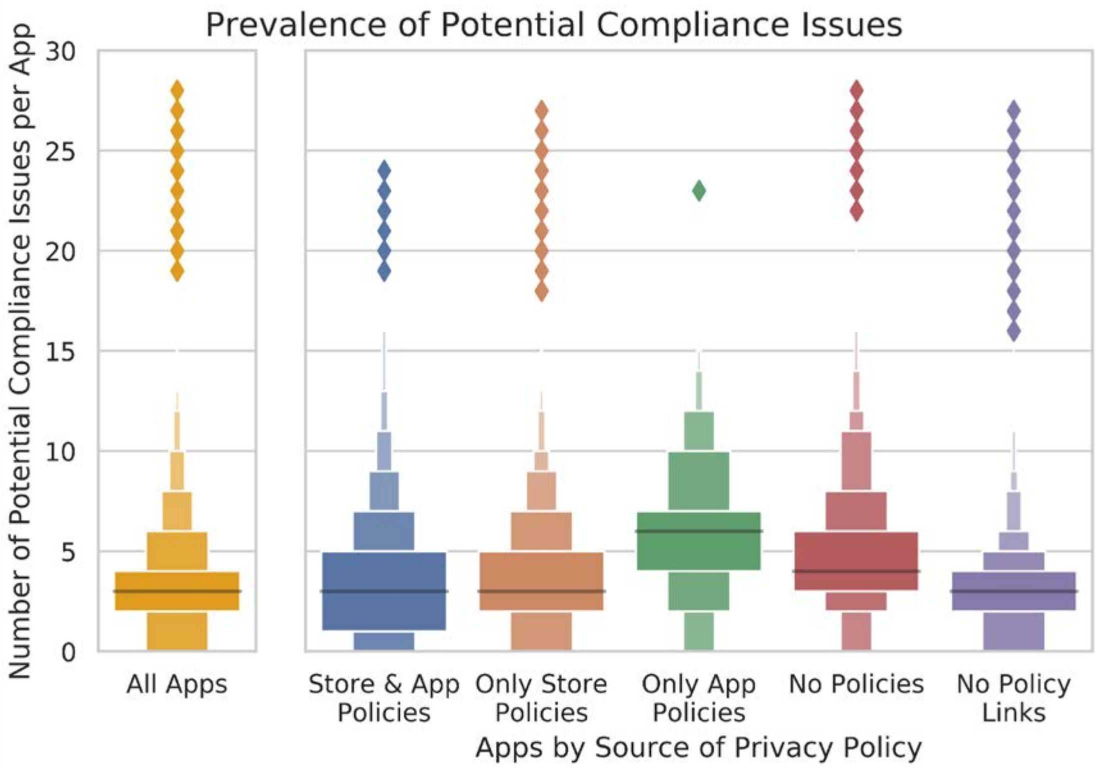

Google Play Store Metadata
Data Retrieval
Privacy Policies
Apps
ML Analysis
Data Analysis
Static Analysis
Compliance with privacy laws, cases, and regulations?

- Training **machine learning classifiers** to extract relevant policy statements
- Compare these statements against:
  - **Regulatory requirements**
  - What the software actually does
    - **Static and dynamic code analysis**

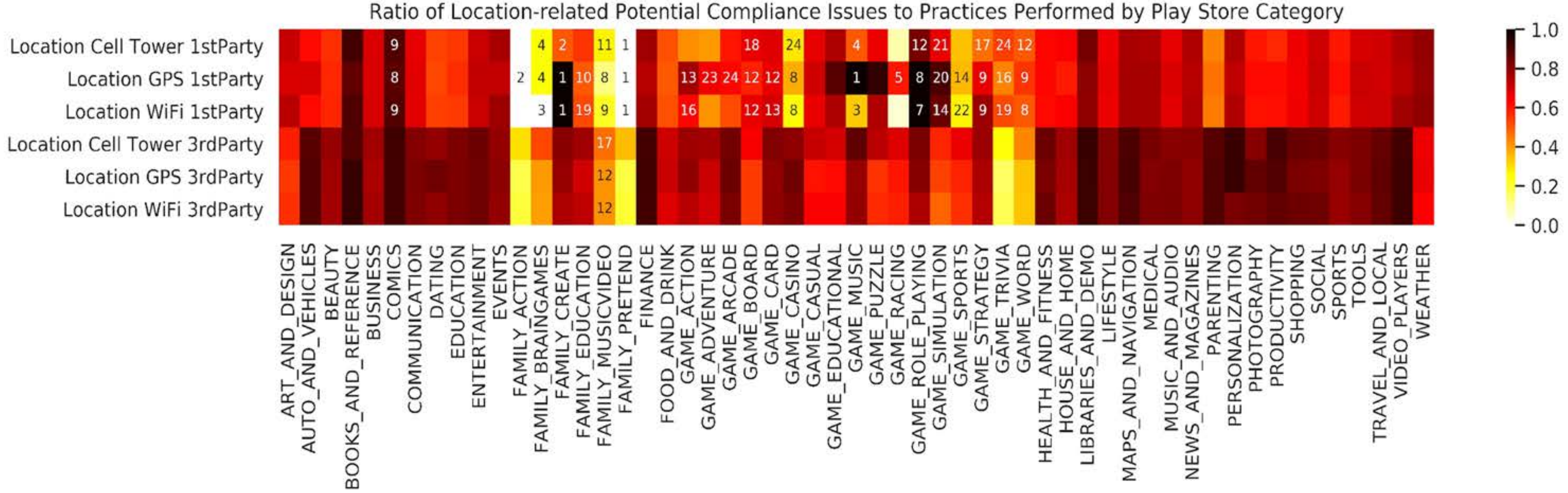
Zimmeck, S., Story, P., Smullen, D., Ravichander, A., Wang, Z., Reidenberg, J., Russell, N.C., Sadeh, N., “MAPS: Scaling Privacy Compliance Analysis to a Million Apps,”in Proceedings on Privacy Enhancing Technologies, Vol. 3, pp. 66-86, 2019. https://doi.org/10.2478/popets-2019-0037

Analysis of over 1 million Android Apps in Google Play Store

- Average number of potential compliance issues per app is 3.47 and the median is 3
- Requires manual vetting – both policy and app behavior to confirm potential compliance issue



Developers Struggle with 3rd Party APIs

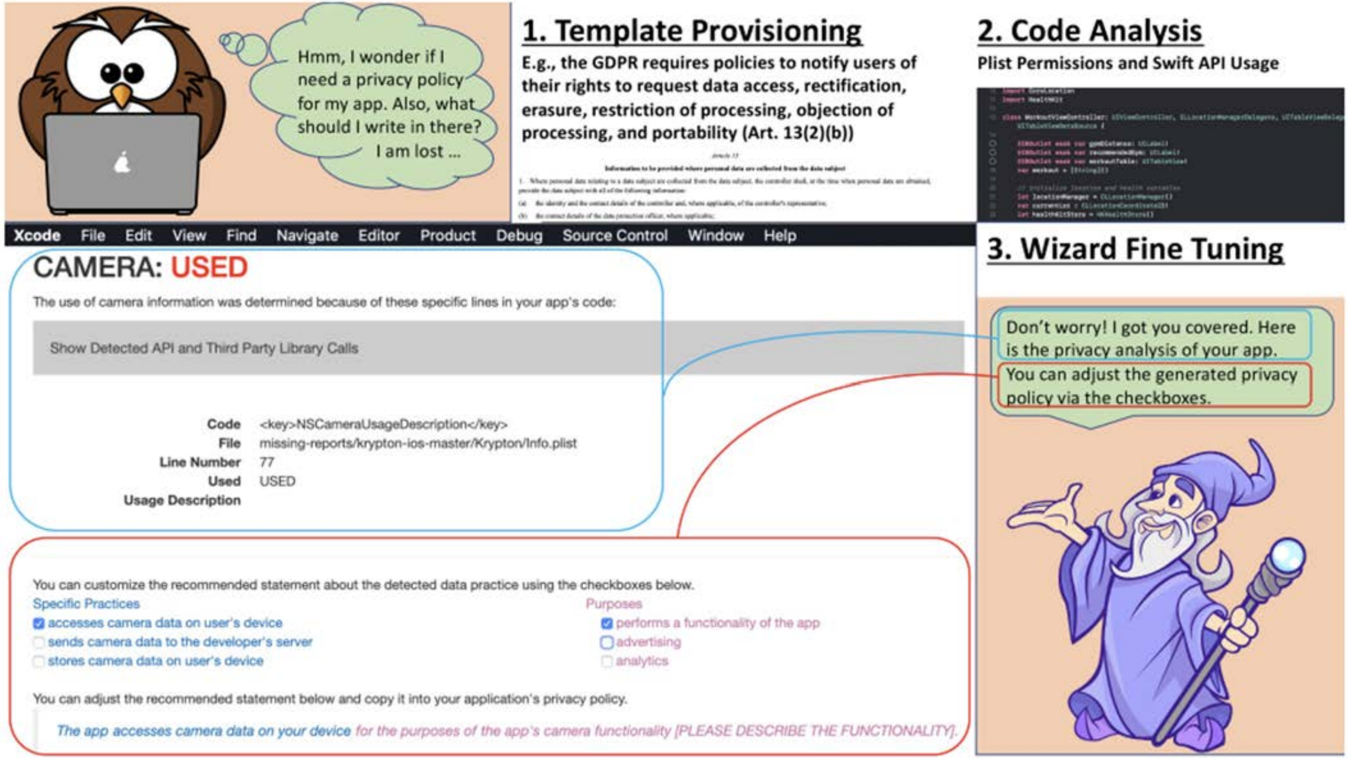


- Lighter colors indicate greater transparency of practices. Darker colors indicate that practices are being performed but not disclosed.
- Cells with fewer than 25 apps performing the practice are annotated with the respective number of apps.

Other Collaborations

- Collaboration with California Attorney General’s office
- COPPA report compiled for Federal Trade Commission
  - Focusing on location, apps with a large number of downloads, and companies based in the US
- CDT report on mobile apps for connected cars
- Work with large European electronics manufacturer – checking for GDPR compliance of mobile apps

Tools for Developers


Hmm, I wonder if I need a privacy policy for my app. Also, what should I write in there? I am lost …
Xcode File Edit View Find Navigate Editor Product Debug Source Control Window Help
Don't worry! I got you covered. Here is the privacy analysis of your app.
You can adjust the generated privacy policy via the checkboxes.

1. Template Provisioning

E.g., the GDPR requires policies to notify users of their rights to request data access, rectification, erasure, restriction of processing, objection of processing, and portability (Art. 13(2)(b))

Article 13

Information to be provided where personal data are collected from the data subject

1. Where personal data relating to a data subject are collected from the data subject, the controller shall, at the time when personal data are obtained, provide the data subject with all of the following information:

(a) the identity and the contact details of the controller and, where applicable, of the controller's representative;

(b) the contact details of the data protection officer, where applicable;

2. Code Analysis

Plist Permissions and Swift API Usage

```
import CoreLocation
import HealthKit

class WorkoutViewController: UIViewController, CLLocationManagerDelegate, UITableViewDelega
    UITableViewDataSource {

    @IBOutlet weak var gymDistance: UILabel!
    @IBOutlet weak var recommendedGym: UILabel!
    @IBOutlet weak var workoutTable: UITableView!
    var workout = [String]()

    // initialize location and health variables
    let locationManager = CLLocationManager()
    var currentLoc : CLLocationCoordinate2D!
    let healthKitStore = HKHealthStore()
```

3. Wizard Fine Tuning

CAMERA: USED

The use of camera information was determined because of these specific lines in your app's code:

Show Detected API and Third Party Library Calls

Code	<key>NSCameraUsageDescription</key>
File	missing-reports/krypton-ios-master/Krypton/Info.plist
Line Number	77
Used	USED
Usage Description	

You can customize the recommended statement about the detected data practice using the checkboxes below.

Specific Practices	Purposes
☑ accesses camera data on user's device	☑ performs a functionality of the app
□ sends camera data to the developer's server	□ advertising
□ stores camera data on user's device	□ analytics

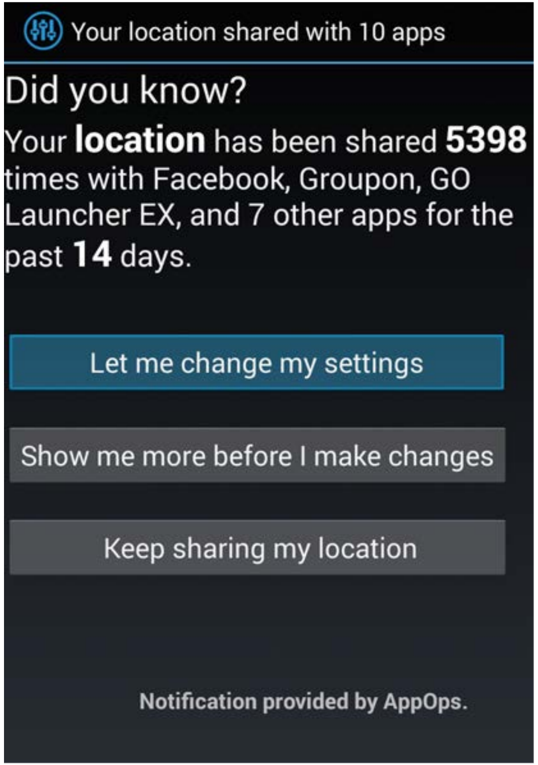
You can adjust the recommended statement below and copy it into your application's privacy policy.

The app accesses camera data on your device for the purposes of the app's camera functionality [PLEASE DESCRIBE THE FUNCTIONALITY].

Compliance traceability: Privacy policies as software development artifacts, S Zimmeck, P Story, R Goldstein, D Baraka, S Li, Y Feng, N Sadeh, Privacy, Usability and Transparency Workshop (PUT 2019) at PoPETs 2019 conference

Could Computers Also Help Motivate People to Take Advantage of Privacy Settings?

Nudging Users: Surprise People with Something That Will Motivate Them to Pay Attention

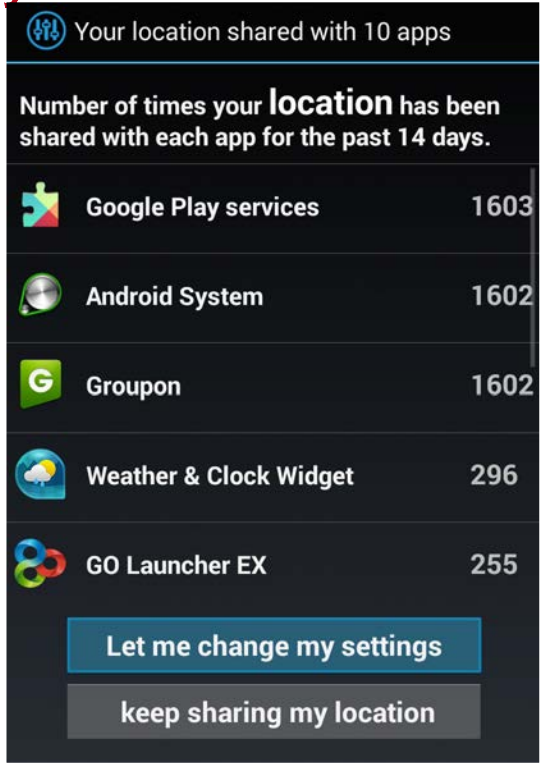


Your location shared with 10 apps

Did you know?

Your **location** has been shared **5398** times with Facebook, Groupon, GO Launcher EX, and 7 other apps for the past **14** days.

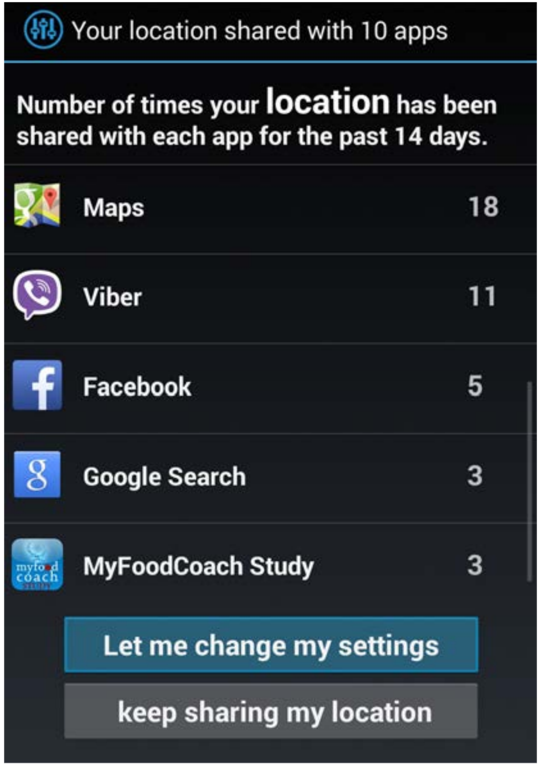
Notification provided by AppOps.



Your location shared with 10 apps

Number of times your **location** has been shared with each app for the past 14 days.

Google Play services	1603
Android System	1602
Groupon	1602
Weather & Clock Widget	296
GO Launcher EX	255



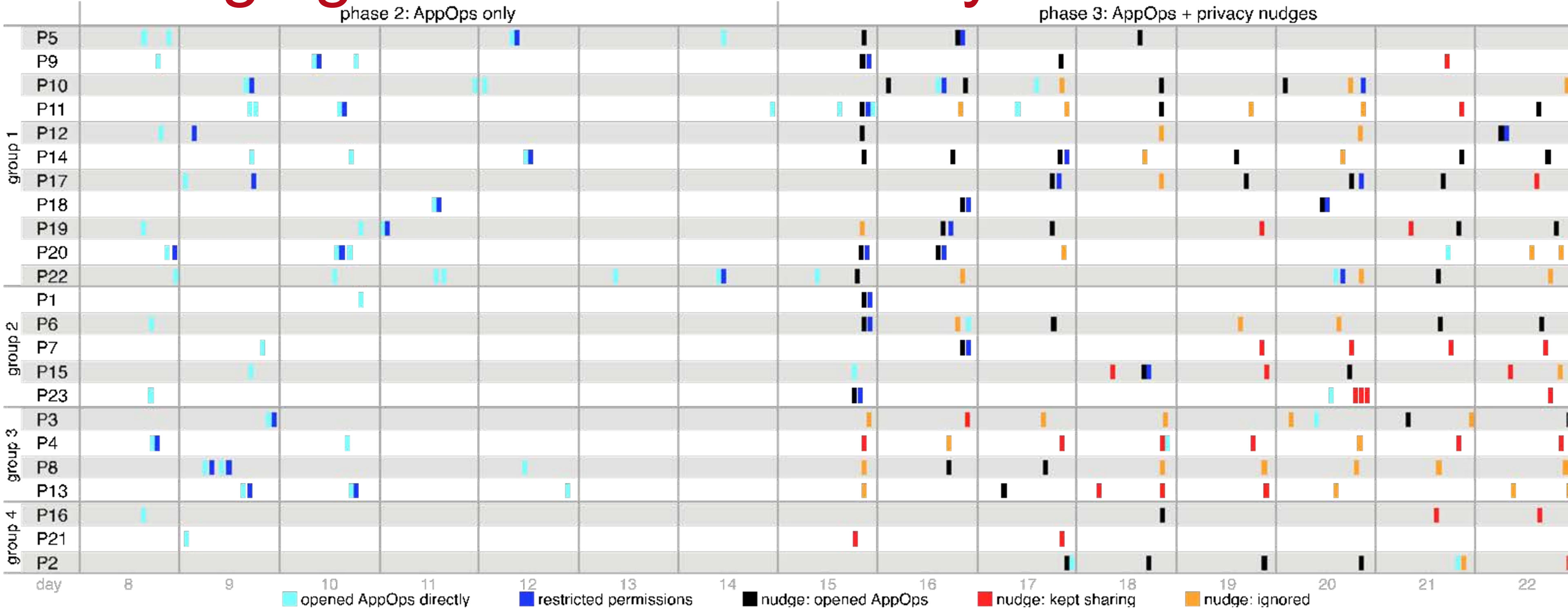
Your location shared with 10 apps

Number of times your **location** has been shared with each app for the past 14 days.

Maps	18
Viber	11
Facebook	5
Google Search	3
MyFoodCoach Study	3

H. Almuhimedi,F. Schaub, N. Sadeh, I. Adjerid, A Acquisti, J. Gluck, L. Cranor, Y. Agarwal, "Your Location Has Been Shared 5,398 Times!: A Field Study On Mobile App Privacy Nudging," ACM CHI 2015.

Nudging Pilot – 3-week study

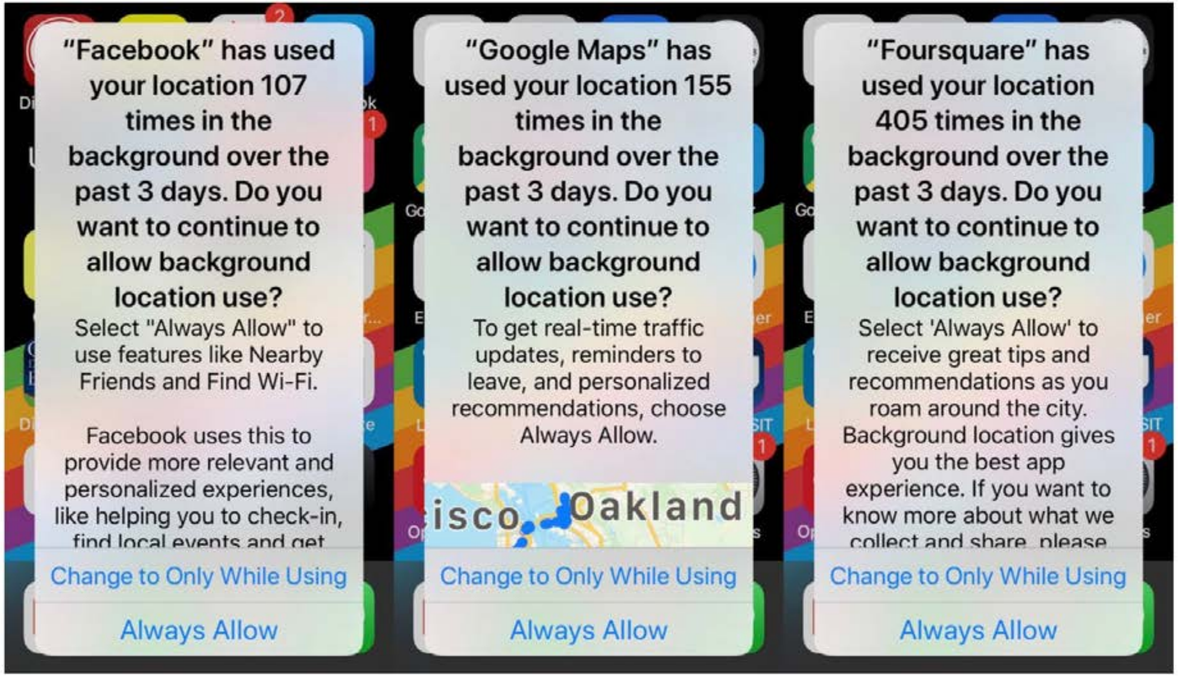


Week 2: Permission Manager Only

Week 3: Daily Nudges

- Permission Manager Helps (week 2)
- Nudges can make a big difference (week 3)

Introduced in iOS13 – Privacy Reminders



“Facebook” has used your location 107 times in the background over the past 3 days. Do you want to continue to allow background location use?

Select "Always Allow" to use features like Nearby Friends and Find Wi-Fi.

Facebook uses this to provide more relevant and personalized experiences, like helping you to check-in, find local events and get

“Google Maps” has used your location 155 times in the background over the past 3 days. Do you want to continue to allow background location use?

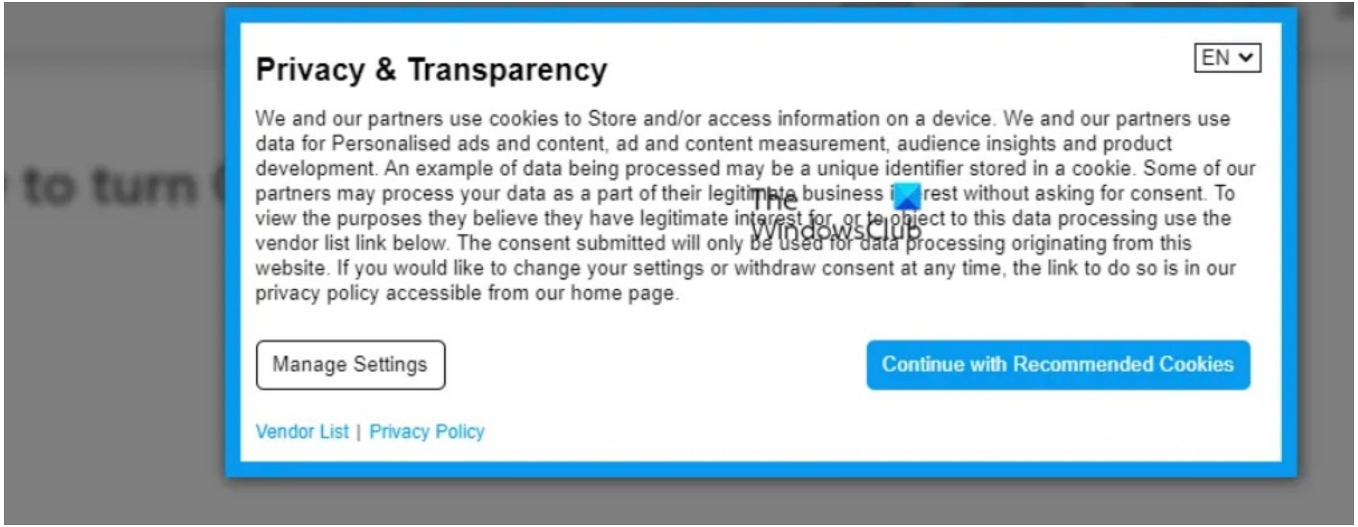
To get real-time traffic updates, reminders to leave, and personalized recommendations, choose Always Allow.

“Foursquare” has used your location 405 times in the background over the past 3 days. Do you want to continue to allow background location use?

Select 'Always Allow' to receive great tips and recommendations as you roam around the city. Background location gives you the best app experience. If you want to know more about what we collect and share, please

Could Computers Help People Manage their Privacy Controls?

Many Privacy Decisions Are Repetitive, Similar and Tedious



Privacy & Transparency

We and our partners use cookies to Store and/or access information on a device. We and our partners use data for Personalised ads and content, ad and content measurement, audience insights and product development. An example of data being processed may be a unique identifier stored in a cookie. Some of our partners may process your data as a part of their legitimate business interest without asking for consent. To view the purposes they believe they have legitimate interest for, or to object to this data processing use the vendor list link below. The consent submitted will only be used for data processing originating from this website. If you would like to change your settings or withdraw consent at any time, the link to do so is in our privacy policy accessible from our home page.

Manage Settings
Continue with Recommended Cookies
Vendor List | Privacy Policy

Standardized APIs could really help…

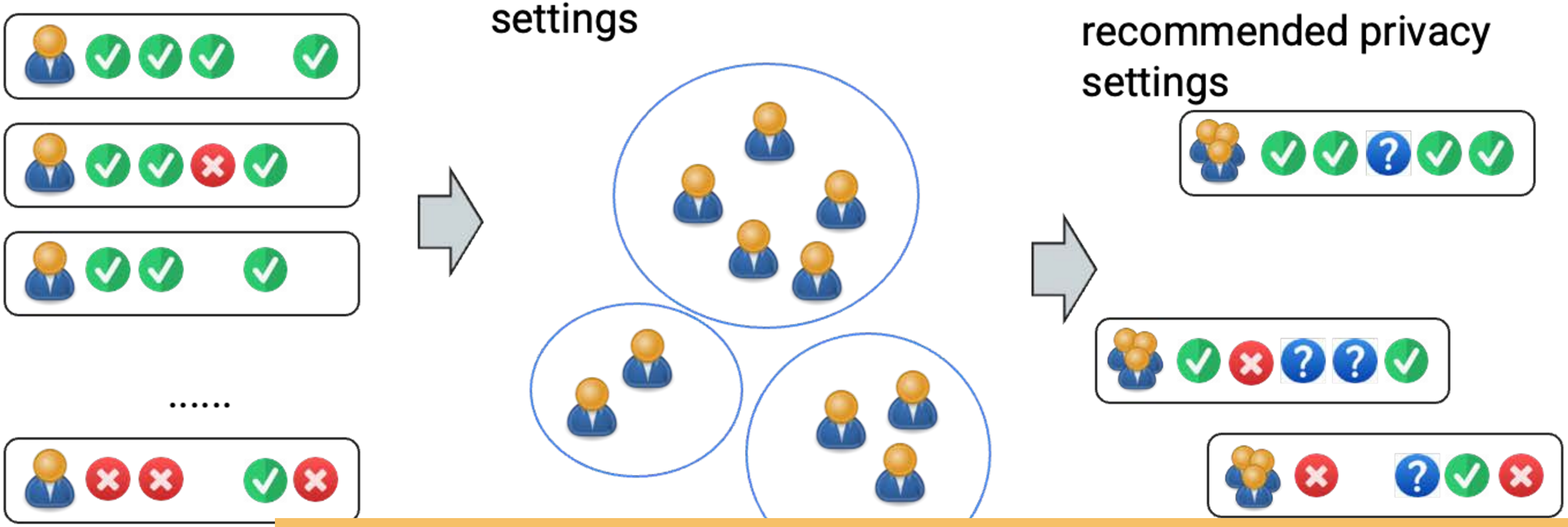
Privacy Assistant: Help users configure their privacy settings – motivates users, mitigate dark patterns, reduce user burden

Privacy Assistants - I

Users with their settings

Clustering of users based on features extracted from their settings

Each cluster has an associated set of recommended privacy settings

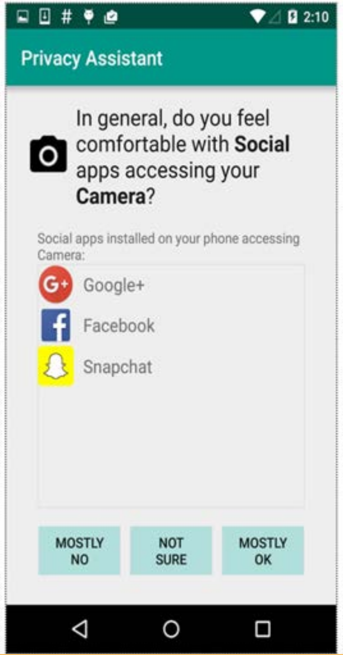


Even simple solution with small number of clusters achieves high levels of accuracy

B. Liu, M.S. Andersen, F. Schaub, H. Almuhimedi, S. Zhang, N. Sadeh, A. Acquisti, and Y. Agarwal, **"Follow My Recommendations: A Personalized Assistant for Mobile App Permissions"**, SOUPS 2016- US patents 10,956,586

Privacy Assistants II

Generating recommendations rather than automating privacy decisions



2:10

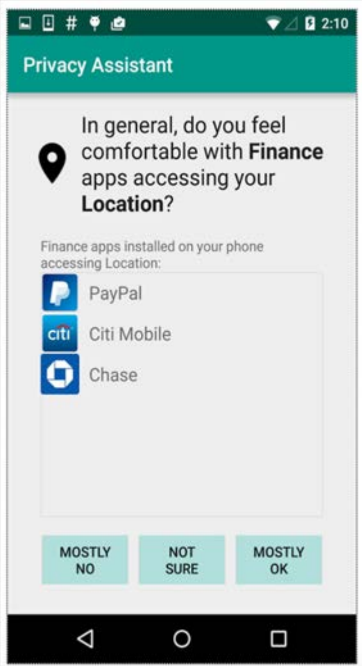
Privacy Assistant

In general, do you feel comfortable with **Social** apps accessing your **Camera**?

Social apps installed on your phone accessing Camera:

- Google+
- Facebook
- Snapchat

MOSTLY NO | NOT SURE | MOSTLY OK



2:10

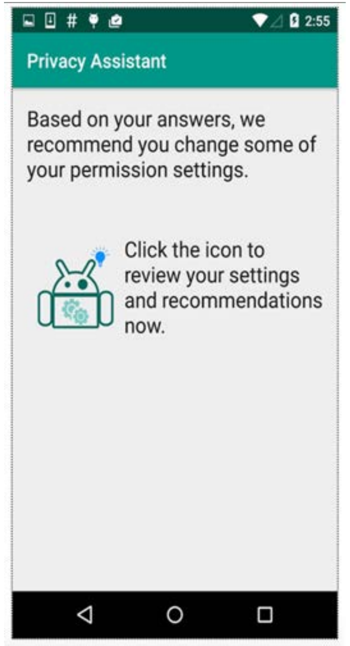
Privacy Assistant

In general, do you feel comfortable with **Finance** apps accessing your **Location**?

Finance apps installed on your phone accessing Location:

- PayPal
- Citi Mobile
- Chase

MOSTLY NO | NOT SURE | MOSTLY OK

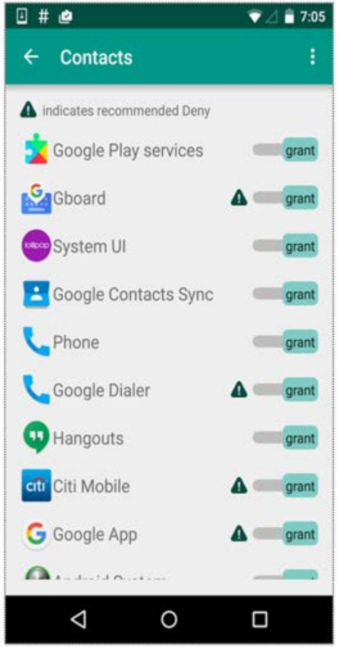


2:55

Privacy Assistant

Based on your answers, we recommend you change some of your permission settings.

Click the icon to review your settings and recommendations now.



7:05

Contacts

⚠ indicates recommended Deny

Google Play services		grant
Gboard	⚠	grant
System UI		grant
Google Contacts Sync		grant
Phone		grant
Google Dialer	⚠	grant
Hangouts		grant
Citi Mobile	⚠	grant
Google App	⚠	grant

Vast majority of recommendations accepted by users and kept despite nudges to reconsider
Successfully deployed in Google Play store for several users – rooted Android phones only…

Why Recommendations?

Agency is a major part of privacy: users should remain in charge of their decisions…but **AI can help** them make these decisions and can help overcome fundamental **usability limitations**

- **Major requirement**: the recommendations have to be ***understandable*** and ***auditable***

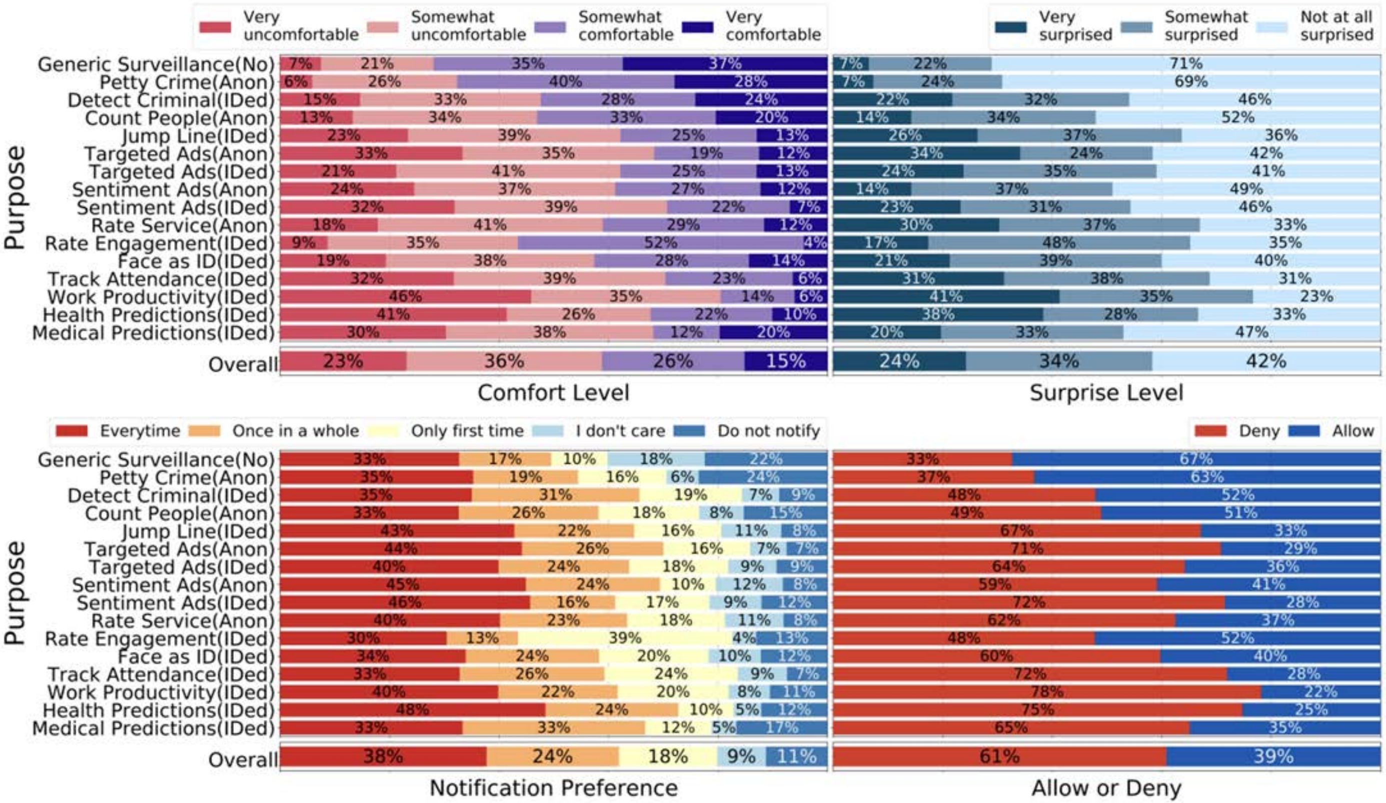
Similar Results with Other Privacy Decisions

- Similar results with browser and IoT privacy decisions
- The challenge is that access to these privacy settings is generally not open
- **Would need regulation to make this possible…**
  - **…just think about the number of times you answer the same cookie questions…**

-S. Zhang, Y. Feng, A. Das, L. Bauer, L. Cranor, N. Sadeh, ‘**Understanding People’s Privacy Attitudes Towards Video Analytics Technologies’,** CMU Sch. of Comp. Sci. Tech Report, CMU-ISR-20-114.

-Daniel Smullen, Yuanyuan Feng, Shikun (Aerin) Zhang, Norman Sadeh, **"The Best of Both Worlds: Mitigating Trade-offs Between Accuracy and User Burden in Capturing Mobile App Privacy Preferences"**, Privacy Enhancing Technologies Symposium (PETS 2020), Sep 2019 [pdf]

In situ study of 123 people over 10 days in the context of their regular day-to-day activities



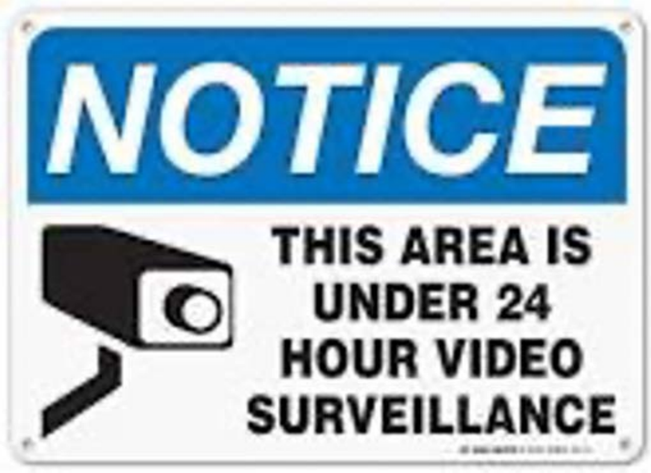
Deployment of a wide range of videoanalytics technologies: Very clear need for effective notification and control functionality

Very Clear Need for APIs and Privacy Assistants

Zhang, Y Feng, L Bauer, LF Cranor, A Das, and N Sadeh, **"“Did you know this camera tracks your mood?”: Understanding Privacy Expectations and Preferences in the Age of Video Analytics"**, Proceedings on Privacy Enhancing Technologies, 2, 1, Apr 2021 [pdf]

How about the Internet of Things?

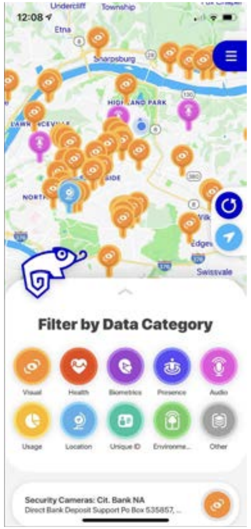
IoT: Additional Usability Challenges



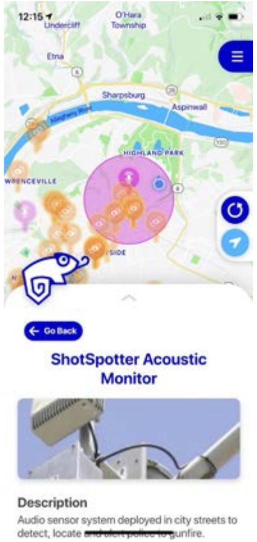
- How likely are you to notice this sign?
- Does this include facial recognition?
- What about facial expression or scene recognition?
- How long is the data retained?
- Do I get to opt in/opt out?
- Is this GDPR compliant?

An IoT Privacy Inafrastructure

- Portal to help people publicize the presence and data practices associated with IoT systems, incl. privacy controls (e.g. opt-in/out, deletion, etc.)
- IoT Assistant app (Android and iOS) for users to discover nearby IoT systems and their data practices, incl. accessing any available privacy controls

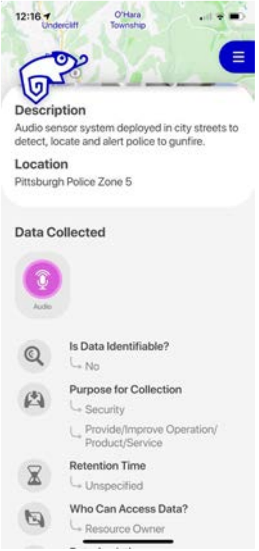


Security Cameras: Cit. Bank NA
Direct Bank Deposit Support Po Box 535857, ...



ShotSpotter Acoustic Monitor

Description
Audio sensor system deployed in city streets to detect, locate and alert police to gunfire.



Description
Audio sensor system deployed in city streets to detect, locate and alert police to gunfire.

Location
Pittsburgh Police Zone 5

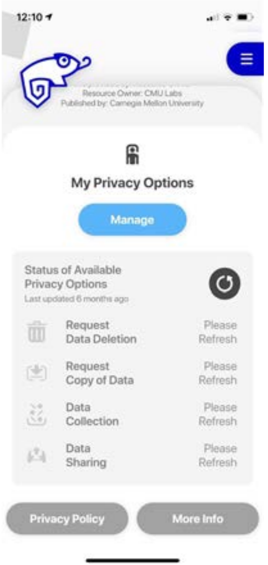
Data Collected

Is Data Identifiable?
No

Purpose for Collection
Security
Provide/Improve Operation/Product/Service

Retention Time
Unspecified

Who Can Access Data?
Resource Owner



Resource Owner: CMU Labs
Published by: Carnegie Mellon University

My Privacy Options

Status of Available Privacy Options
Last updated 6 months ago

Request Data Deletion	Please Refresh
Request Copy of Data	Please Refresh
Data Collection	Please Refresh
Data Sharing	Please Refresh

https://www.iotprivacy.io

US Patents 10,956,586 with additional USPTO and EPO patents pending

IoT Privacy Infrastructure

- The IoT Assistant App video
- IoT Privacy Infrastructure Overview video
- Hosting nearly 150,000 IoT system entries today

A. Das, M. Degeling, D. Smullen, and N. Sadeh, Personalized Privacy Assistants for the Internet of Things, 2018 IEEE Pervasive Computing: Special Issue - Securing the IoT, April 2018

Concluding Remarks - I

- Privacy is becoming **increasingly complex**
  - Everyone is collecting our data, increasingly complex data flows
  - Smartphones, IoT, AI/ML
- **New regulations** have been introduced that are in great part motivated by these developments (e.g., GDPR, CCPA/CPRA)
- These regulations are an important step in the right direction
- **Yet, in the absence of better technologies, they make usability even more challenging**
- AI is requiring people to take an increasingly broad view of privacy…Moving towards **a broader range of ethical considerations (e.g., from “access” to interpretability, explainability, “tweakability”)**

Concluding Remarks - II

- My collaborators and I have been working on the development of technologies that aim to **mitigate these usability challenges**
- **Some successes over the years**
    - Introduction of increasingly finer permission settings in iOS and Android
    - Introduction of privacy labels in iOS and Android
    - Privacy nudges (e.g., Facebook, iOS)
    - Automated compliance tools for developers and regulators
    - Opt-Out Easy browser extension
    - Influences on public policy discussions/regulations (e.g. CCPA/CPRA, ADPPA)

Concluding Remarks - II

- Our vision: **Privacy Assistants** that leverage
  - Techniques designed to empower people to take **advantage of more detailed privacy policy disclosures**
  - Techniques designed to motivate people and assist them with the **management** of an increasingly unmanageable number **of privacy decisions**
- Using techniques such as AI/ML or privacy nudges gives rise to complex **ethical issues** and requires **careful evaluation**
- Some of our efforts to help people manage their privacy settings call for **regulations that mandate privacy APIs** - **without these APIs privacy will remain unmanageable.**
- **Especially true in the Internet of Things**

Q&A

The **Usable Privacy Policy Project** and the **Personalized Privacy Assistant Project** involve collaborations with a number of individuals

More details at:

https://usableprivacy.org

https://privacyassistant.org

https://explore.usableprivacy.org

https://www.iotprivacy.io